Ecosystem Function and Values of Wetlands and Waters of the U.S. for the Honolulu High-Capacity Transit Corridor Project

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DRAFT DOCUMENT

Introduction

This document presents the approach and results of a functional assessment of riparian and aquatic environments of waters of the U.S. for the Honolulu High-Capacity Transit Corridor Project (HHCTCP; the "Project"). A description of the affected environments is provided in the report *Wetlands and Waters of the U.S. Study, July 10, 2009, Honolulu High-Capacity Transit Corridor Project*. The locations and references made herein to numbered sites (1 through 31) come from that document.

The 31 sites surveyed were grouped by categories based in part on the nature of the potential jurisdictional waters at the site, but principally on the nature of the impact of the Project on aquatic resources at each site. Five categories (I through V), ranging from lowest potential impact to greatest potential impact, were defined, with Category I (4 sites) representing an absence of waters of the U.S. (and therefore no possible impact on aquatic resources and requiring no further consideration in this document), Categories II through IV (18 sites) representing waters of the U.S. present but no Project structural elements proposed for those waters, and finally Category V (9 sites) representing waters of the U.S. present and structural elements potentially encroaching on those waters. Only the Category V sites require detailed consideration with regard to either Section 404 of the Clean Water Act and/or Section 10 of the Rivers and Harbors Act. However, some secondary impacts (for examples, runoff and shading) are potential at Category II, III, and IV sites.

Regulations emphasize that mitigation is only to be considered after avoidance and minimization of impacts. Alternatives and planning and engineering aimed at avoiding or minimizing impacts on aquatic resources are discussed in Chapter 2 of the FEIS for the

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Project, and in a separate 404(b)(1) analysis document. The present document examines the magnitude of the project effects anticipated after consideration of all alternative approaches (unavoidable impacts) and extends consideration of the nature of these impacts from strictly an amount (length, area, or volume) of fill (Table 1) to impacts on ecosystem functions and values at each affected site. Further, this document contributes to the baseline information for impact and proposed mitigation sites and the mitigation site selection justification as required by USACE guidelines for mitigation plans (USACE, 2005). However, a separate Mitigation Plan document will be prepared during the Project permitting phase to fulfill all requirements for an acceptable mitigation.

Table 1. Project area/volume of fill and linear stream impacts in waters of the U.S.

		Waiawa Stream	Waiawa Spring	Moanalua Stream	Kapalama Canal	Nu'uanu Stream	Total
CONSTRUCTION IMPACTS	Total Impact Area (acres)	0.06	--	0.002	0.06	0.00	0.12
	Total Impact Volume (CY) (below OHWM & above mudline)	300	--	11	511	35	857
	Total Impact Volume (CY) (below mudline)	0	--	305	1,633	276	2,214
PERMANENT IMPACTS	Total Impact Area (acres)	0.003	0.06	0.004	0.01	0.004	0.08
	Total Impact Volume (CY) (below OHWM & above mudline)	10	185	8	61	27	291
	Total Impact Volume (CY) (below mudline)	873	0.00	1,454	60	1,164	3,551
	Linear feet of impact along stream	16	100	6	33	6	161

Background

Natural and "semi-natural" ecosystems provide a wide range of ecological and socio-economic goods and services (Odum & Odum, 1972). Ecosystem functions are the physical, chemical, and biological attributes of a system without regard to their usefulness or importance to human society. Thus, interactions of biota and the physical world in a given location are necessary for an ecosystem to exist and maintain, although some of these functions result in various benefits to mankind that can be valued. Thus, values are not the structure and functions that enable an ecosystem to exist, but a subset of these that give benefit to humans (de Groot, Wilson, and Boumans, 2002). A good working definition for this subset is "the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly" (de Groot, 1992).

An assessment of ecosystem functions and values (Functional Assessment) has become a standard accompaniment to any activity that requires a state or federal permit and which is anticipated to require some level of mitigation for unavoidable adverse impacts arising from the action. An environmental assessment (EA or EIS) serves this purpose to some extent, but more formalized approaches have been steadily gaining acceptance since the late 1980s and are now emphasized in rule-making for CWA actions (USACE, 2008a). Indeed, wetland assessment procedures are now so numerous and varied that procedural approaches to selecting a wetland assessment method have become necessary (Bertoldus, 1999a, 1999b, 2000). The functional assessment approach follows from the requirement that an ecosystem approach be used when determining compensatory mitigation requirements, replacing a strictly area-of-impact approach in most cases (USACE, 2002). The mitigation objective becomes one of achieving no net loss of (wetland or aquatic) ecosystem functions and values rather than acreage or area *per se*. For streams, mitigation generally means the manipulation of the physical, chemical, and/or biological characteristics of a stream with the goal of repairing or replacing its natural functions (USACE, 2008b).

Application for a Department of the Army Permit through the Army Corps of Engineers (ACOE) under Section 404 of the Clean Water Act (CWA) and/or Section 10 of the Rivers and Harbors Act requires a functional assessment (33 CFR §325.1 (d)(7) as amended) of rigor commensurate with the anticipated level of impact (USACE, 2002, 2008a). Bertoldus (1999a) reviewed 40 different wetland assessment methods, many of which are applicable to aquatic environments other than wetlands. This latter requirement is important here because the Project only involves direct impacts on stream and estuary systems, with at most shading imposed on a few wetland environments. Typically, these assessment methods involve identifying functions and values specific to the aquatic environment impacted by the project, developing (or applying developed) metrics or metric scores representing a range of conditions for each function or value, and arriving at a total score or index value representing a quantification of the resources; the score can then be used to assess before and after conditions of an activity or establish a level of mitigation commensurate with the impacts. This approach allows flexibility in establishing an acceptable mitigation, because it is not necessary to replace each diminished function or value with an identical function or value enhanced to match.

Approach

The Hydrogeomorphic Approach (HGM) used by the USACE recognizes three categories of function: hydrologic function, physical process functions (e.g., biogeochemical functions), and biological functions related to habitat. The approved Corps HGM approach requires development of assessment models which are calibrated based on reference sites, and is therefore not useful in the present situation: the impact sites are almost all stream and estuary environments in highly modified (man-made) channels. Models have not been developed for these environments in Hawaiʻi.

The approach used herein to evaluate compensatory mitigation requirements for the Project is as follows: 1) Each site where the linear transportation project is adjacent to or crosses a waters of the U.S.[2] was visited and rated on a three-point scale for each of 22 function or value categories as modified (after Groot, et al., 2002). 2) A NRCS (2001) visual assessment method developed for Hawaiʻi was completed for each of the stream sites. 3) For stream sites where an actual impact is anticipated based upon design plans, the method and form developed by the Little Rock District of the ACOE (USACE, 2008b) for stream assessment was completed. This "Little Rock District Method" was deemed applicable in this assessment for two reasons: a) impacts of the project are relatively minor, calling for a simple and straightforward approach; and b) methods developed for more typical streams in Hawaiʻi and elsewhere are just not applicable to highly modified, estuarine reaches where impacts are occurring from the Project. Many of the streams encountered in the Little Rock District (Mississippi Valley) are flood plain streams that have been modified (e.g., diked) for flood control purposes, a characteristic in common with the lowland stream and estuarine reaches of the urban stream segments crossed by the Project structures. The NRCS method is a simplified or rapid approach to stream assessment utilized for many years on Hawaiian streams. Although a more detailed approach has since been developed (Kido, 2008), this IBI method is not useful for estuaries because it compares sites with mountain reference streams.

Although regulations suggest (but do not require) mitigation within the same watershed, the impacts of the Project amount to several small impacts in different watersheds (each stream crossing is a different watershed) that would individually, if commensurate with the amount and type of impact, be difficult to separately apply (keep within the same watershed as the impact) and achieve a lasting effect. Impacted watersheds could be more broadly defined on the basis of the nearby receiving water body for the estuary: these would be Pearl Harbor, Keʻehi Lagoon, and Honolulu Harbor. Of the three, Pearl Harbor has the greatest potential for benefit from a mitigation effort directed at improving functions within a contributing stream system if only for the reasons that it is the largest estuarine environment (i.e., of a type closer to the environments impacted) and is the most enclosed and therefore most sensitive to land impacts. Our approach is to consolidate mitigation at

[2] The Project approach is to seek a preliminary jurisdictional determination for these waters. For the purposes of this document, all waters (including intermittent and ephemeral streams) are considered waters of the U. S. if they fit the definitions of tidal, wetland, RPW, or non-RPW waters. Sites 1 and 2 involve portions of Kaloʻi Gulch, a modified drainage on the ʻEwa Plain with no natural outlet. The Corps has recently confirmed that they will not assert jurisdiction over Kaloʻi Gulch and therefore these sites become Category I sites and are removed from consideration in this report.

a single site (Site 12) located on Waiawa Stream. However, engineered approaches that take into account the ecosystem functions and values at each stream/estuary crossing have been subjected to review with consideration to the Washington (state) Department of Fish and Game, *Integrated Streambank Protection Guidelines* (2003).

Waiawa Stream has been selected over an estuary location for the mitigation because of the availability of land that is part of the Project where enhancement of the stream and potentially establishment of a riverine wetland are possible with a high degree of success into perpetuity. That is, the mitigation area would become part of the Project. Although the Project has minimal effect on the stream at Site 12, it will have a considerable effect on the riparian area at that location. Further, if the "spring" located there (Site 13) is jurisdictional, the impact area of constructing a culvert to direct the spring flow away from beneath the Pearl Highlands station comprises about two-thirds of the linear stream impacts and three-quarters of the acreage of the permanent Project impacts under USACE jurisdiction (Table 1).

Because Waiawa Stream at the Project (Site 12) is a natural stream, a field survey of this area using more sophisticated stream assessment methods (such as the IBI approach; Kido, 2008) would be justified to establish a preconstruction baseline against which the mitigation effort can later be monitored.

Results

Table 2 lists various properties and functions of ecosystems in column 1 (modified from de Groot, Wilson, and Boumans, 2002 and USEPA,). The functions are grouped into broad categories to facilitate understanding. These categories are: 1) regulation functions, 2) habitat functions, 3) production functions, and 4) information functions. Briefly, regulation functions control essential ecological processes and life support systems, providing the benefits of clean air, clean water, and biological controls. Habitat functions are the provisions of habitat for wild plants and animals. This function contributes to biotic diversity. Production functions relate to the uptake of energy and nutrients to produce biomass. In many cases, such biomass can be harvested for direct human consumption, or can contribute through the food chain to harvestable resources. Information values are varied, but centered around the concept that positive human experiences can derive from access to the natural world and include spiritual, scientific, aesthetic, and recreational opportunities.

The typology presented by de Groot, Wilson, and Boumans (2002) is not included in its entirety, but pared down to relate easily to aquatic systems. Consideration is given to both the aquatic component and the non-aquatic component (e.g., riparian zone) in considering the functions represented by a location. Furthermore, this consideration does not here

Table 2. List of ecosystem functions and values applied to Project effected aquatic sites.

	Site 4 Hono'uli'uli Str	Site 6 Hō'ae'ae Str	Site 7 Waikele Str	Site 9 Kapakahi Str	Site 10 Waipahu Canal	Site 11B Middle Loch
Wetland Present	No	No	No	No	No	Yes
Jurisdictional Waters Present	Yes	Yes	Yes	Yes	Yes	Yes
Project Effects Anticipated	<2>	<2>	<2>	<2>	<2>	<3>
Visual Assessment Score †	0.92	0.11	0.58	1.01	0.31	---
Regulation functions						
Climate regulation	+	-	o	o	-	+
Regulation of runoff and discharge	+	+	+	+	+	o
Water supply - filtration, storage	+	-	o	+	-	o
Sediment/soil retention	+	-	-	+	+	+
Soil Formation	o	o	o	o	o	o
Nutrient regulation, storage, recycling	o	o	+	+	+	+
Waste treatment and recycling	o	o	o	o	o	o
Biological Control - trophic dynamic	o	o	+	o	o	+
Habitat functions						
Refuge for aquatic fauna	o	-	+	+	+	+
Reproduction/nursery function	-	-	+	+	+	+
Feeding/foraging habitat	-	-	+	+	+	+
Production functions & values						
Edible plants and animals	-	-	o	o	+	+
Renewable raw materials	-	-	o	o	o	o
Genetic resources in wild biota	-	-	o	o	o	+
Medicinal resources	-	-	o	o	o	+
Ornamental resources	-	-	o	o	o	o
Information values						
Aesthetics	+	-	+	+	-	+
Recreation	o	-	o	o	+	+
Cultural value	o	o	o	o	o	o
Spiritual	+	o	-	o	-	+
Historical value	o	o	o	o	o	+
Science and education value	o	o	o	+	+	+
Score	-1	-13	5	9	5	15

Table 2 (continued).

	Site 12 Waiawa Str	Site 13 "Spring"	Site 14 Pearl City Str	Site 15 Waiau Spring	Site 16 Waimalu Str	Site 17 Kalauao Spring
Wetland Present	No	No	No	Yes	Yes	Yes
Jurisdictional Waters Present	Yes	Yes	Yes	Yes	Yes	Yes
Effects Anticipated	<2,3>	<1,2,3>	<2>	<2>	<2>	<2>
Visual Assessment Score	1.55	0.83	0.28	1.04	0.48	0.86
Regulation functions						
Climate regulation	+	o	-	+	o	+
Regulation of runoff and discharge	+	+	+	+	+	+
Water supply - filtration, storage	+	+	-	+	o	+
Sediment/ soil retention	+	-	-	+	+	+
Soil Formation	o	+	o	+	o	+
Nutrient regulation, storage, recycling	+	+	+	+	+	+
Waste Treatment and recycling	o	o	o	+	o	+
Biological Control - trophic dynamic	+	o	-	+	+	+
Habitat functions						
Refuge for aquatic fauna	+	+	-	+	+	+
Reproduction/nursery function	+	+	-	+	+	+
Feeding/foraging habitat	+	+	-	+	+	+
Production functions						
Edible plants and animals	+	+	o	+	+	+
Renewable raw materials	o	o	o	o	o	o
Genetic resources in wild biota	+	+	o	+	+	+
Medicinal resources	o	o	o	+	o	+
Ornamental resources	o	o	o	+	o	+
Information functions/values						
Aesthetics	+	+	-	+	-	+
Recreation	+	+	-	+	+	-
Cultural value	o	o	o	+	o	o
Spiritual	+	o	o	+	o	o
Historical value	o	o	o	o	o	+
Science and education value	+	+	o	+	+	+
Score	15	11	-7	20	10	17

Table 2 (continued).

	Site 18 Kalauao Str	Site 19 ʻAiea Str	Site 22 Halawa Str	Site 25 Aolele Ditch	Site 27 Moanalua Str	Site 28 Kalihi Str
Wetland Present	No	No	Yes	No	No	No
Jurisdictional Waters Present	Yes	Yes	Yes	Yes	Yes	Yes
Effects Anticipated	<2>	none	<2>	<2,3>	<1,2,3>	<2>
Visual Assessment Score	0.90	0.28	0.68	0.20	0.37	0.50
Regulation functions						
Climate regulation	o	o	+	+	+	+
Regulation of runoff and discharge	+	+	+	+	+	+
Water supply - filtration, storage	o	-	o	o	o	o
Sediment/soil retention	+	+	+	+	+	+
Soil formation	o	o	o	o	o	o
Nutrient regulation, storage, recycling	+	+	+	+	+	+
Waste treatment and recycling	o	o	o	+	o	o
Biological control - trophic dynamic	+	+	+	+	+	+
Habitat functions						
Refuge for aquatic fauna	+	+	+	+	+	+
Reproduction/nursery function	+	+	+	+	+	+
Feeding/foraging habitat	+	+	+	+	+	+
Production functions						
Edible plants and animals	o	+	+	o	+	+
Renewable raw materials	o	o	o	o	o	o
Genetic resources in wild biota	+	+	+	+	+	+
Medicinal resources	o	o	o	o	o	o
Ornamental resources	o	o	o	o	o	o
Information functions/values						
Aesthetics	+	+	+	+	+	+
Recreation	o	+	+	o	+	+
Cultural value	o	o	o	o	o	o
Spiritual	o	o	o	o	o	o
Historical value	o	o	o	o	o	o
Science and education value	+	+	+	+	+	+
Score	10	11	13	12	13	13

Table 2 (continued).

	Site 29 Kapalama Canal	Site 30 Nuuanu Str	Site 31 Paankauahi Gulch
Wetland Present	No	No	No
Jurisdictional Waters Present	Yes	Yes	Yes
Effects Anticipated	<1,2,3>	<1,2,3>	<2>
Visual Assessment Score	0.29	0.16	1.1
Regulation functions			
Climate regulation	+	+	+
Regulation of runoff and discharge	+	+	+
Water supply - filtration, storage	o	o	+
Sediment/soil retention	+	+	+
Soil Formation	o	o	+
Nutrient regulation, storage, recycling	+	+	o
Waste Treatment and recycling	o	o	o
Biological Control - trophic dynamic	+	+	o
Habitat functions			
Refuge for aquatic fauna	+	+	-
Reproduction/nursery function	+	+	o
Feeding/foraging habitat	+	+	o
Production functions			
Edible plants and animals	+	+	o
Renewable raw materials	o	o	o
Genetic resources in wild biota	+	+	o
Medicinal resources	o	o	o
Ornamental resources	o	o	o
Information functions/values			
Aesthetics	o	+	+
Recreation	+	+	o
Cultural value	o	o	o
Spiritual	o	o	o
Historical value	o	o	o
Science and education value	+	+	+
Score	12	13	6

Table 2 (continued).

Legend to Table 2

Footnotes:

† - From Stream Visual Assessment Report.

Anticipated Effects:

<1> - Structural encroachment (fill): piling(s), culvert, etc.
<2> - Some degree of shading to jurisdictional waters will occur.
<3> - Direct storm water runoff from guideway or other Project structure.

Table Scoring:

- negative; function or value not enhanced, probably diminished by feature..
o neutral; function or value not or minimally met by aquatic feature.
+ positive; function or value probably met or enhanced by aquatic feature.

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concern itself with whether the function is compromised or directly/indirectly impacted by the Project. For each of the 21 locations (of 31 sites originally inspected) along the proposed transit route where the route or proposed ancillary facilities (stations, parking, access roads, maintenance facilities) are anticipated to impact on either a wetland or other jurisdictional aquatic feature, a plus sign (+) is entered if the location provides to some degree the itemized function or value. A negative sign (-) is used to indicate that conditions present at the site are far less than ideal and may detract from a function or value. A zero (o) is used to indicate a neutral response (neither positive nor negative).

Any number of the methods reviewed by Bertoldus (1999a) could serve as a source or starting point for a listing of functions and values pertinent to streams and wetlands. However, rather than tailor a listing from a method that was specific for a different purpose, starting with the very general typology of de Groot, et al. (2002) and giving thought to the relevance of each of the ecosystem functions and values to the environments encountered by the Project provided a more thorough approach. Removed from the list as proposed by de Groot et al., was Pollination as not having relevance here; several others were combined (for example Disturbance prevention (storms, floods) and Water regulation of runoff and discharge; Air purification/gas regulation combined into Climate Regulation). One (Refugium function) was split into two functions: refuge for aquatic fauna and feeding/foraging habitat.

Table 2 also summarizes scores from a Hawaii Stream Visual Assessment Protocol (HSVAP) undertaken at each stream crossing location. This NRCS method was developed for Hawaiian streams (NRCS, 2001) and uses ten scored elements—including water clarity, plant growth, channel conditions, native species habitats, and riparian conditions—to arrive at a composite score. The Hawaii version is based upon a national model (NRCS, 1998). The technical note transmitting the HSVAP describes the protocol as "provid[ing] a first step, basic level of stream quality evaluation, based primarily on physical conditions."

Scores for the stream locations assessed range from 0.11 to 1.55. Considering that the majority of sites assessed are in modified channels in urban areas at existing bridge sites, the low scores are not unexpected. The highest score (Waiawa Stream, 1.55) represents a perennial freshwater flow in a natural stream channel. The HSVAP defines scores of 1.0 or less as indicating a Low rating; scores between 1.1 and 1.4 are Medium ratings; stream scores between 1.5 and 1.7 are rated High; and scores between 1.8 and 2.0 represent Very High ratings.

Table 2 summarizes the anticipated effects of the project on each aquatic environment. These are 1) structural (fill) elements of the project placed in Waters of the U.S.; 2) shading from the guideway as it crosses or passes over or next to an aquatic environment; and 3) runoff contributed from the guideway more or less directly into an aquatic environment. The structural encroachments will require a Department of the Army permit and these direct impacts are considered further in this document as the basis of the mitigation requirements. Shading is included as an effect where the guideway or other structural elements would shade the aquatic environment to some extent. This effect is extremely variable through the day, in different seasons, and at each location. Because the guideway is elevated, the shading effect is spread out more than it would be for a low roadway bridge; that is, a larger area experiences shading, but the shading tends to be more transitory. Shading reduces both water temperature and primary productivity. Both effects are deemed to be quite small from the narrow footprint of the Project at most locations, and obviously have both positive and negative consequences.

Runoff effects are considered a potential impact only at locations where the structures proposed would capture and divert runoff into an aquatic environment in excess of the situation in the absence of the structure. Thus, because the guideway follows along existing roadway corridors, no additional runoff will be generated since rainfall captured by the structure would have been captured by the roadway and, in most locations, this runoff will be directed into the existing street drain system. The guideway in these cases does not increase runoff to aquatic environments. In the few case where this effect is indicated, the quality of the runoff will be treated by use of on-the-ground biofiltration structures or, where space does not provide for a biofiltration unit, a serviceable filter within the downspouts.

Table 3 provides the first part (scoring system) of the worksheet developed by the Little Rock District of the Army Corps. The table presents values for the metrics in column 1 based upon the characteristics of the stream and the type of activity permitted. It has utility here in that the characteristics are simplified properties, functions, and values that can be easily applied to the impacts on jurisdictional waters assessed for the Project and the stream locations of each proposed fill. Table 4 demonstrates how the approach is applied for each fill location. For each impact site, the factors are generated based upon the category or range of conditions read from Table 3. The results are summarized in Table 4. The following explanations are provided for each decision, modified from the full text given in ACOE (2008b).

Table 3. Adverse Impact Factors for Riverine Systems (ACOE, 2008b).

<table>
<tr><th>METRIC</th><th colspan="9">FACTORS</th></tr>
<tr><td>Stream Type</td><td colspan="3">Ephemeral
0.1</td><td colspan="3">Intermittent
0.4</td><td colspan="3">Perennial
0.8</td></tr>
<tr><td>Priority Area</td><td colspan="3">Tertiary
0.1</td><td colspan="3">Secondary
0.4</td><td colspan="3">Primary
0.8</td></tr>
<tr><td>Existing Condition</td><td colspan="3">Functionally Impaired
0.1</td><td colspan="3">Moderately Functional
0.8</td><td colspan="3">Fully Functional
1.6</td></tr>
<tr><td>Duration</td><td colspan="3">Temporary
0.1</td><td colspan="3">Recurrent
0.1</td><td colspan="3">Permanent
0.3</td></tr>
<tr><td>Activity</td><td>Clearing
0.05</td><td>Bridge Footing
0.15</td><td>Below grade culvert
0.3</td><td>Armor
0.5</td><td>Detention
0.75</td><td>Morphological Change
1.5</td><td>Impoundment (dam)
2.0</td><td>Pipe >100 ft
2.2</td><td>Fill
2.5</td></tr>
<tr><td>Linear Impact</td><td><100 ft
0</td><td>100 to 200 ft
0.05</td><td>201 to 500 ft
0.1</td><td>501 to 1000 ft
0.2</td><td colspan="5">> 1000 linear feet (LF)
0.1 per 500 LF of impact
(e.g., 5280 LF = 1.1)</td></tr>
</table>

Stream Type: Project impacts occur in perennial reaches of each stream.

Priority Area: "Priority area is a factor used to determine the importance of the stream that would be impacted or used for mitigation" (ACOE, 2008b, p. 4). Based upon the examples given in the method, the majority of sites were ranked as secondary: 1) waters on the 303(d) list that are impaired by sediments or nutrients, and 2) stream or river reaches within high growth areas. Primary streams are at least one of the following:

Waters with listed Federal Endangered and Threatened species
National Wild and Scenic Rivers/Study Rivers
Outstanding National Resource Waters
Outstanding State Waters
Extraordinary Resource Waterbodies
Ecologically Sensitive Waters
State Natural and Scenic Waters
Approved greenway corridors

Existing Conditions: Existing conditions represent the state of the physical, chemical, and biological health of a stream as compared with least disturbed condition of similar streams in the region. With the exception of Waiawa Stream, all of the locations were assessed as functionally impaired: "[t]he stream is considered impaired if the reach has been channelized" and "[t]he stream has little or no riparian buffer with deep-rooted vegetation on one or both sides of the stream" and [t]he stream has five or greater stream impacts [culverts, pipes, or other man-made modifications] within 0.5 miles upstream…" (USACE, 2008b, p. 6). Waiawa Stream was scored as moderately functional. To wit: "[t]he stream shows that human-induced sedimentation and erosion is moderate", "[t]he stream has a moderate riparian buffer of deep-rooted vegetation present (minimum of at least 10 feet on both sides of the stream)", and "[t]he stream has no more than three stream impacts within 0.5 miles upstream of the proposed stream impact, including culverts, pipes, or other manmade modifications (with less than 100 feet of impacted section)" (USACE, 2008b, p. 6).

Table 4. Calculations of "Mitigation Credits" for the impact sites.

		Waiawa Stream	Waiawa "Spring"	Moanalua Stream	Kapalama Canal	Nu'uanu Stream
Metric Scores	**Stream Type**	0.8	0.8	0.8	0.8	0.8
	Priority Area	0.4	0.4	0.4	0.4	0.4
	Existing Condition	0.8	0.1	0.1	0.1	0.1
	Duration	0.3	0.3	0.3	0.3	0.3
	Activity	0.05	0.3	0.15	0.15	0.15
	Linear Impact	0	0.05	0	0	0
Calculations	**Sum of Factors (M)**	2.4	1.9	1.8	1.8	1.8
	Linear Feet of stream impacted in reach (LF)	1800	100	6	33	6
	Credit Deficit (M x LF)	4320	190	11	58	11

Duration: Duration is the amount of time adverse impacts are expected to last: in the case of the Project impacts (as opposed to construction impacts) these are permanent. Although the construction impacts will have a larger area of impact, the duration is less (factor = 0.1). The two types of impacts could be calculated separately.

Activity: This metric is scored on the basis of the structural impact type. All have been scored for bridge footings except Waiawa Stream (Site 12) and the nearby spring (Site 13). In the latter case, the activity is essentially one of a pipe or open culvert, ~100 ft long. At Waiawa Stream, the main activity is clearing in the riparian area. While this latter activity is not meant to be a permanent one, the metric score is low, suggesting that was the intent in the protocol.

Linear Impact: Linear impact is defined as the length of the stream, in feet, that will be impacted as authorized by the Department of the Army Permit for which mitigation will be required. The activity for most of the sites having permit requirements under Section 404 or Section 10 that are under 100 LF of stream (see Table 1).

Calculations: The Little Rock Method calculates a Mitigation Credits Required score as the grand total of the sum of factors times the linear feet of impacted stream (M x LF). This grand total is to be balanced by mitigation credits calculated by a similar process, establishing the minimum mitigation required for a project. The mitigation credits required in this case could be 4590. An interesting result, however, is how these credits breakdown by location. The placement of piers within the streams at four locations account for a requirement to mitigate 61 credits (Waiawa Stream pilings included). The bulk of the credit requirement derives from removing vegetation along Waiawa Stream (Site 12).

The proposed mitigations for the Project are scored using separate worksheets (USACE, 2008b). The following statement defines the purpose of this part of the calculations:

> Compensatory stream mitigation involves the restoration, creation, enhancement, or for streams of national or state significance because of the resources they support, preservation of streams and their associated floodplains. The purpose is to compensate for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization have been achieved. Compensatory mitigation may be required for impacts to perennial, intermittent, and ephemeral streams and should be designed to restore, enhance, and maintain stream uses that are adversely impacted by authorized activities (USACE, 2008a).

The type of mitigation (riparian buffer or stream channel creation, enhancement, restoration, or preservation) determines the applicable form. Details of the process are too lengthy, running to several pages, to include in entirety here, so the instructions should be consulted for any deviations from what is presented here. The calculation of mitigation credits generated for a restoration of the riparian buffer at Site 12 on Waiawa Stream entails the following scoring (Table 5) and calculation (with reasoning following each score as provided in the instructions and work sheets):

Table 5. Riparian buffer creation, enhancement, restoration, and preservation metrics (ACOE, 2008b).

METRIC	SCORING FACTORS			
Stream Type	Ephemeral 0.05	Intermittent 0.2	Perennial 0.4	
Priority Area	Tertiary 0.05	Secondary 0.2	Primary 0.4	
Net Benefit	Livestock (from table)	Riparian creation, enhancement, restoration, and preservation (from ACOE, 2009b, Table 1)		
System Protection Credit	Conditional: MBW restored or protected on both stream banks. To calculate: (Net Benefit Stream Side A + Net Benefit Stream Side B)/2			
Monitoring Contingency	Level I 0.05	Level II 0.15	Level III 0.25	
Control	No Covenant / Restrictive Covenant 0.05	Conservation Easement/ Deed Restrictions 1.5		
Credits (each side)	Schedule 1 0.15	Schedule 2 0.05	Schedule 3 0	
Temporal Lag (yrs)	Over 20 -0.3	10 to 20 -0.2	5 to 10 -0.1	0 to 5 0

Stream Type:	0.4	Perennial stream (see Table 3)
Priority Area:	0.4	Primary priority area (see Table 3)
Net Benefit		
North Side:	0.0	Slope may be too steep to meet minimum width (= 0.2)
South Side:	0.8	Exotic removal and 51-100% replanted, >100 ft wide
Stream Protection Credit:		
	0.4	Restoration occurring on both sides of stream to extent possible; conservative average
Monitoring:	0.3	Level II[3] monitoring on both sides of stream
Control:	0.05	Restrictive covenant likely (no future development in riparian buffer)
Credits:	0	Mitigation action to be completed after impacts occur
Temporal Lag:	0	Buffer fully functional in 5 years or less.

[3] Level II monitoring from this source entails two of either: 1) photo reference sites, 2) plant survival counts, and 3) stream channel stability measurements. Also required are success/failure criteria and contingency plans in the event of failures. Inclusion of all three and biological monitoring as appropriate is Level III.

The sum of factors from above is 2.35; this value times the linear feet of stream buffer (each side not counted separately) of 1800 ft yields 4230 credits (C = M x LF) using a conservative estimate of the factor scores. Total credits generated would be this number times a Mitigation Factor of 1.0 for in-kind buffer replacement (= 4230 total credits). Additional credits will need to be generated, since there remains a deficit of 270 credits. This deficit can be erased by either achieving greater factor scores in the above calculation or undertaking another mitigation action.

The Sum of Factors in the above calculation could be increased to 2.5 or greater to generate a total credit score of 5440 (beyond the 5387 credits required) or greater by achieving higher credit scores. Possibilities are: a) meeting the minimum buffer width on the north riparian buffer (it is not yet known if the minimum width can be met since this requires knowledge of the finished ground slope; potentially could add up to 0.6); b) addition of a conservation easement to the stream and buffer area (add 0.15); and/or c) enhance monitoring to Level III (add 0.1).

Stream channel restoration or enhancement could also generate mitigation credits. For example, the process appears to allow a credit under Net Benefit for Stream Channel Preservation (no in-stream work/activity), although it is unclear if net benefit (>3000 credits at the Waiawa Stream site) would be applied in conjunction with the proposed riparian enhancements, or would require some stream channel restoration or enhancement activity as well. Even a fairly modest additional effort such as restoring stream bank stability or increasing the area of the floodplain could generate credits in excess of 3000 at the Waiawa Stream site.

Other mitigation credits could be gained by plantings of native trees and ground covers at other locations where a clear benefit could be achieved (such as at Sites 28 or 29). Just by way of example, consider planting of natives in a 50 ft by 200 ft strip on both levees up and downstream of the Project crossing of Kāpalama Canal. Assuming that the west bank cannot meet the minimum buffer width but both sides are planted, total credits generated could be 430. This greatly exceeds the credits required for all of the sites with fill in jurisdictional waters (61), although not an in-kind aquatic resource replacement, a fact taken into account by applying a Mitigation Factor of 0.5 instead of 1.0.

[Add Washington State stuff here if applicable mitigations can be found]

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